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(52) UK CL (Edition O)
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GB 2214355 A **GB 2174548 A** **GB 2023818 A**

(58) Field of Search
UK CL (Edition N) **G1D DH10X**
INT CL[6] **F03G 7/06 , G01K 11/00 , G08B 17/06 , G12B 1/00**
ONLINE:WPI

(54) Thermal actuator for liquid heating vessels

(57) A steam sensor control for an electrically heated water boiling appliance comprises a thermally-responsive actuator in the form of a helix 9 of Titanium-Nickel-Copper alloy shape memory effect (SME) material. The actuator develops a high force and substantial movement and enables a sealed steam sensor control to be achieved wherein the switching contacts 5, 6 of the control are housed within a body part of the control and are isolated from the SME sensor, which is on the outside of the control body part, by a diaphragm seal 7 formed of silicone rubber, the diaphragm seal 7 having an integrally moulded push-rod 8 which on the steam (wet) side of the diaphragm serves as a mounting for the SME helix and on the dry side operates the switching contacts, 5, 6 via a bistable trip lever 3.

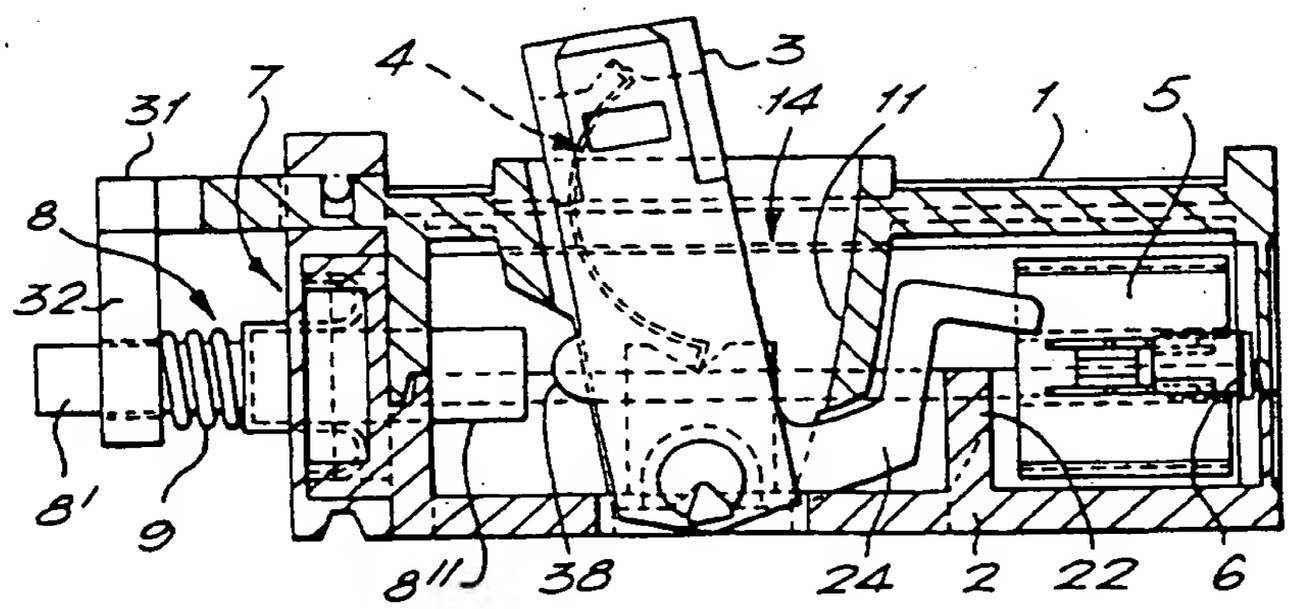


FIG. 2B.

GB 2 299 859 A

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

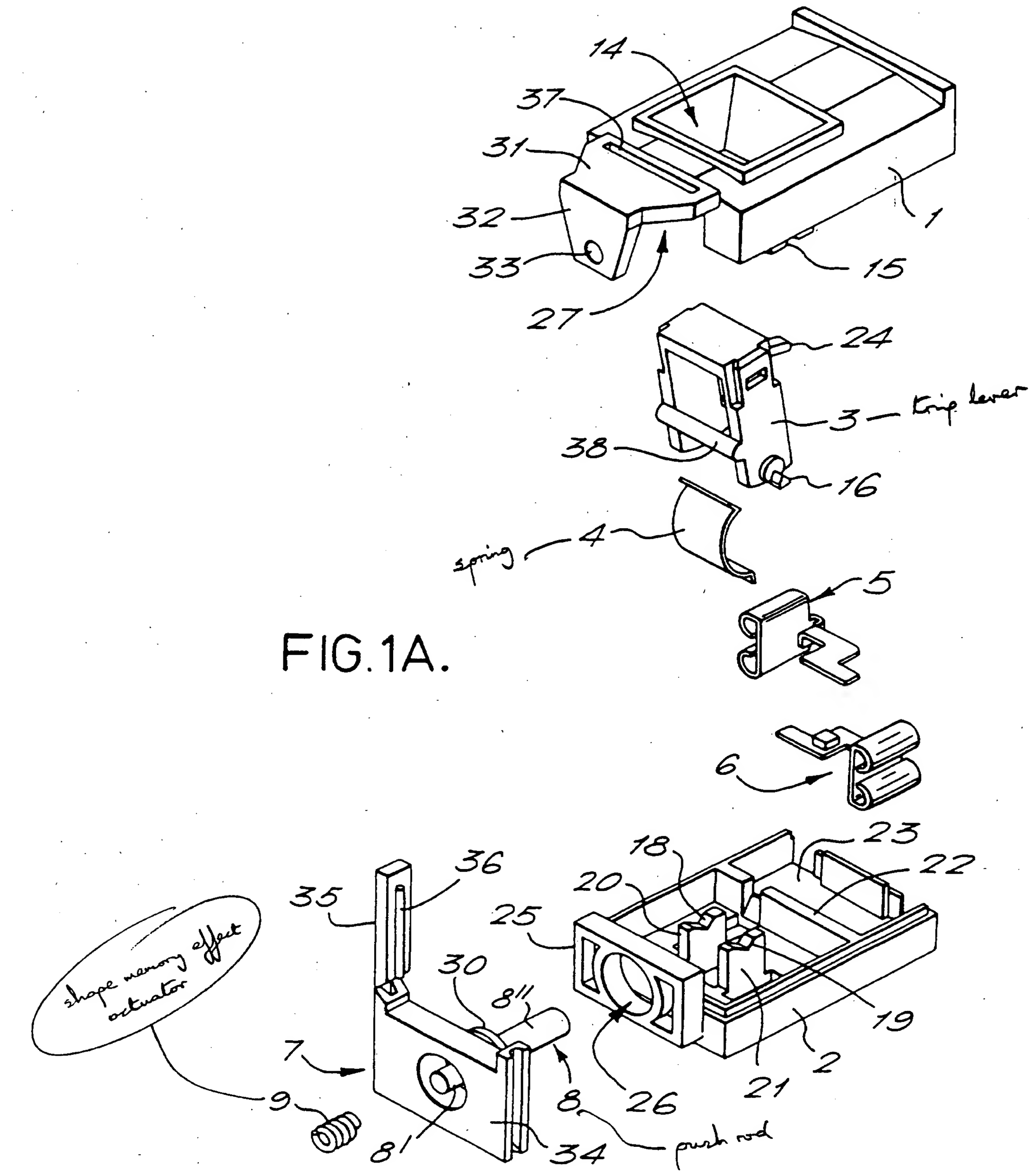

14
37
31
32
33
27
1
15
24
3
trip lever
38
16
spring
4
5
6
shape memory effect actuator
36
35
30
8''
7
9
8'
34
18
20
25
23
22
19
2
21
26
8
push rod

FIG.1A.

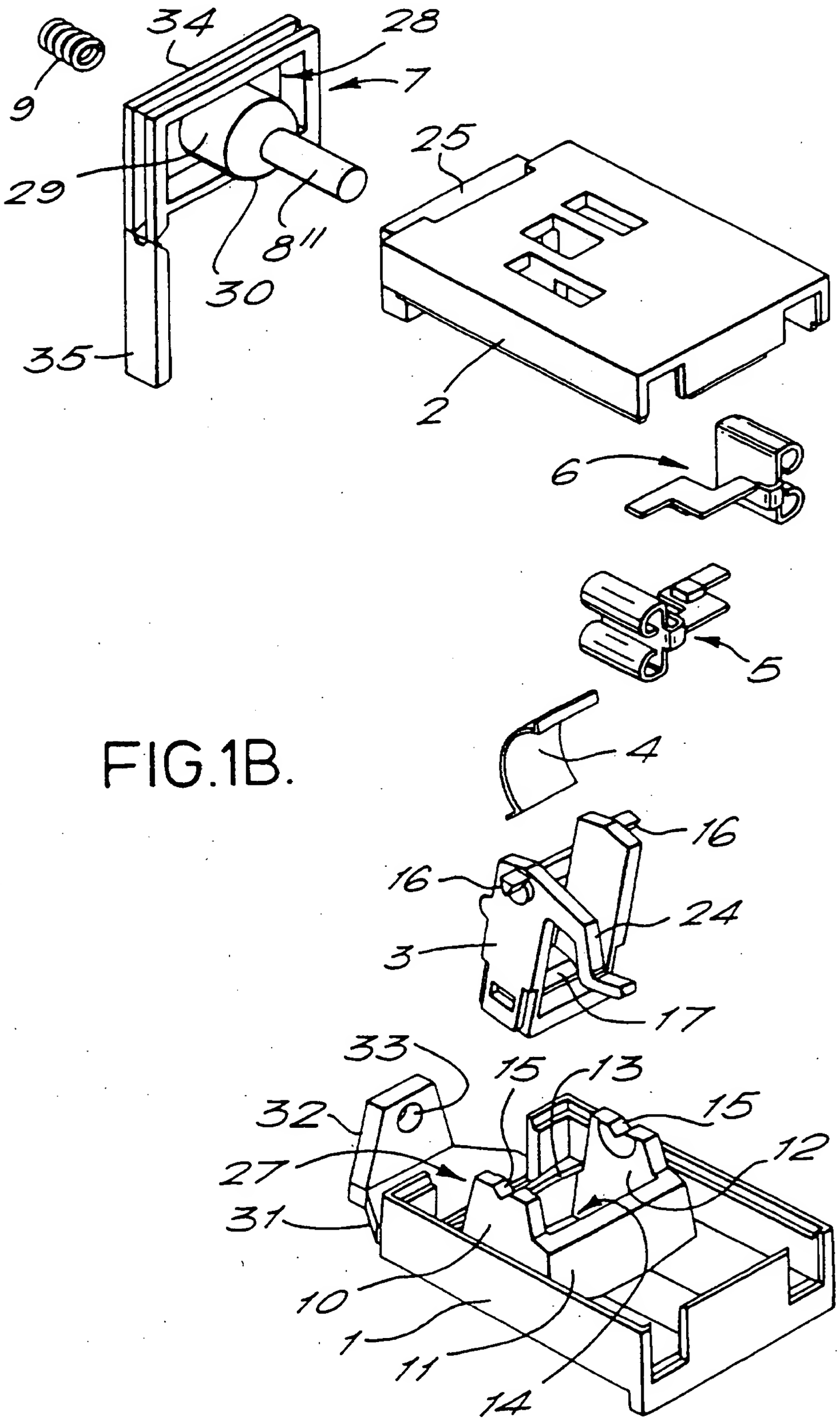
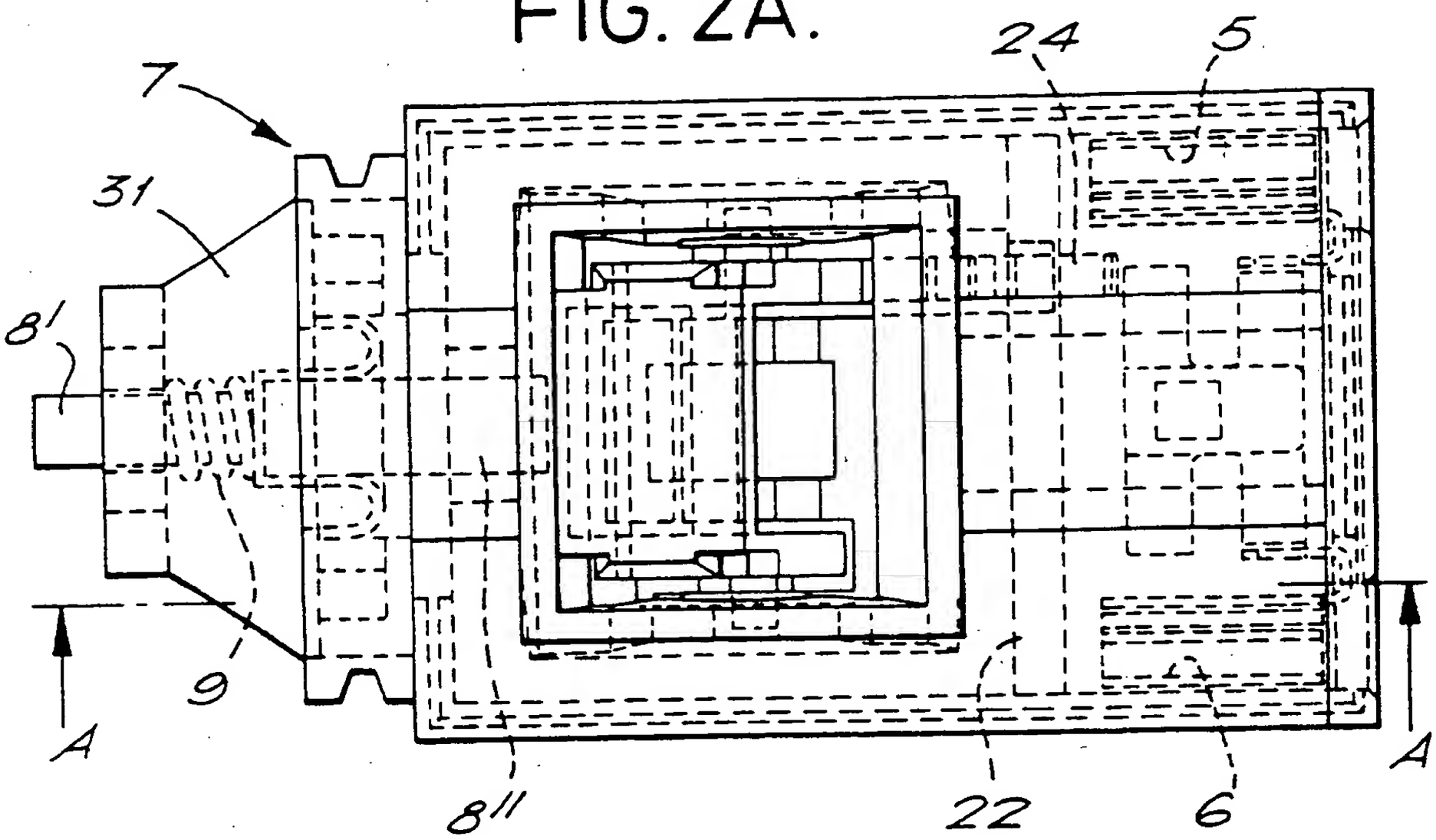

34
28
9
7
29
25
8''
30
35
2
6
5
4
16
16
24
3
17
33
15
13
32
15
27
12
31
10
1
11
14

FIG.1B.

FIG. 2A.


24
5
7
31
8'
9
A
A
8''
22
6

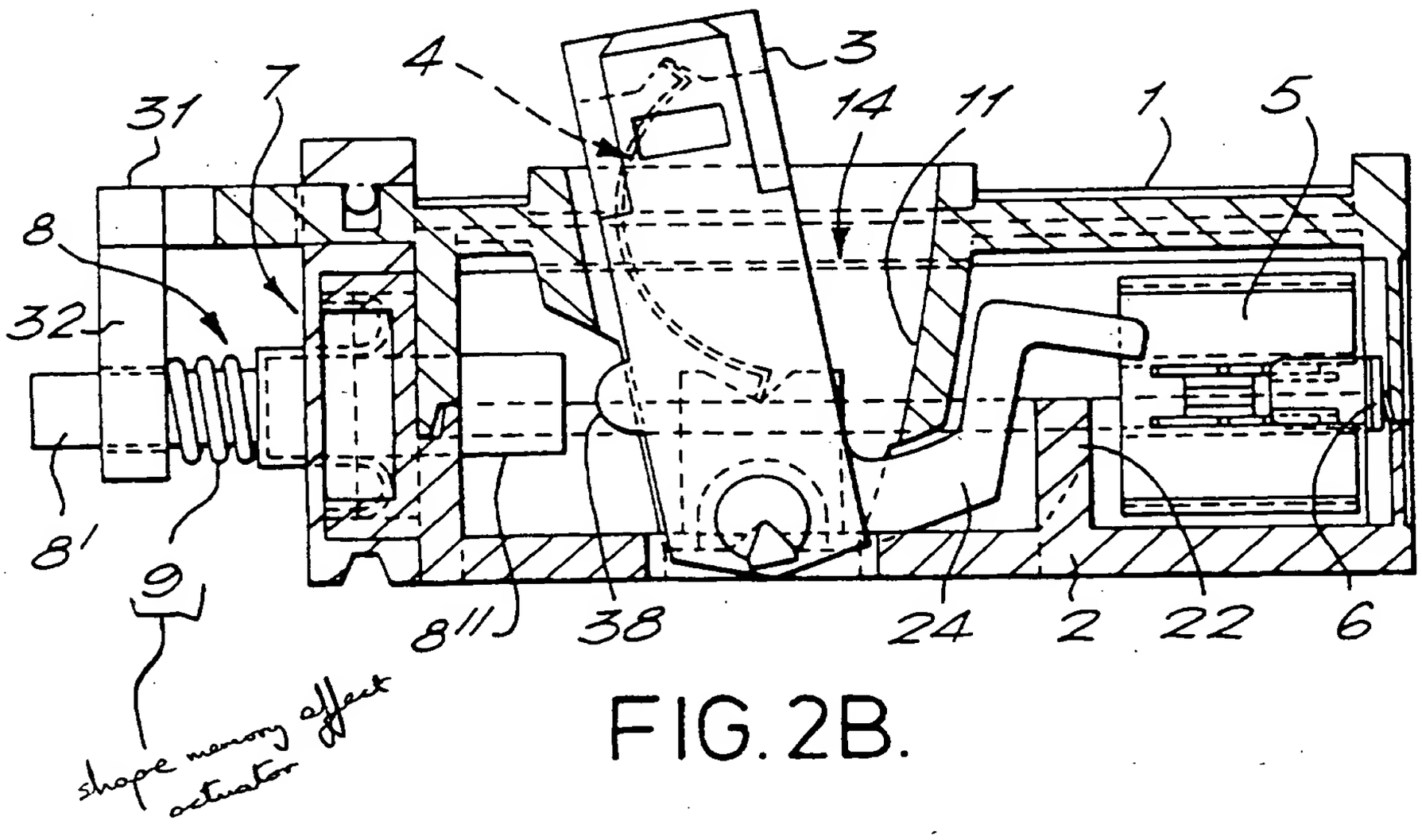

3
4
7
31
14
11
1
5
8
32
8'
9
8''
38
24
2
22
6
shape memory effect actuator

FIG. 2B.

FIG. 2C.

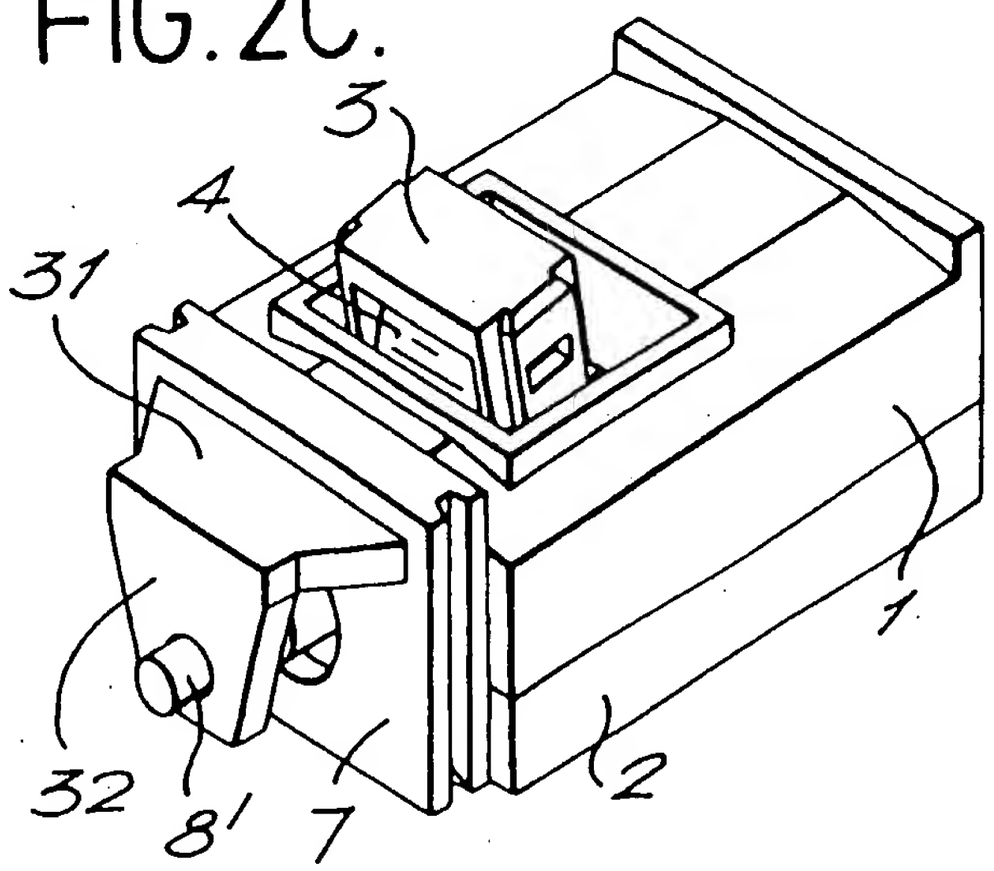
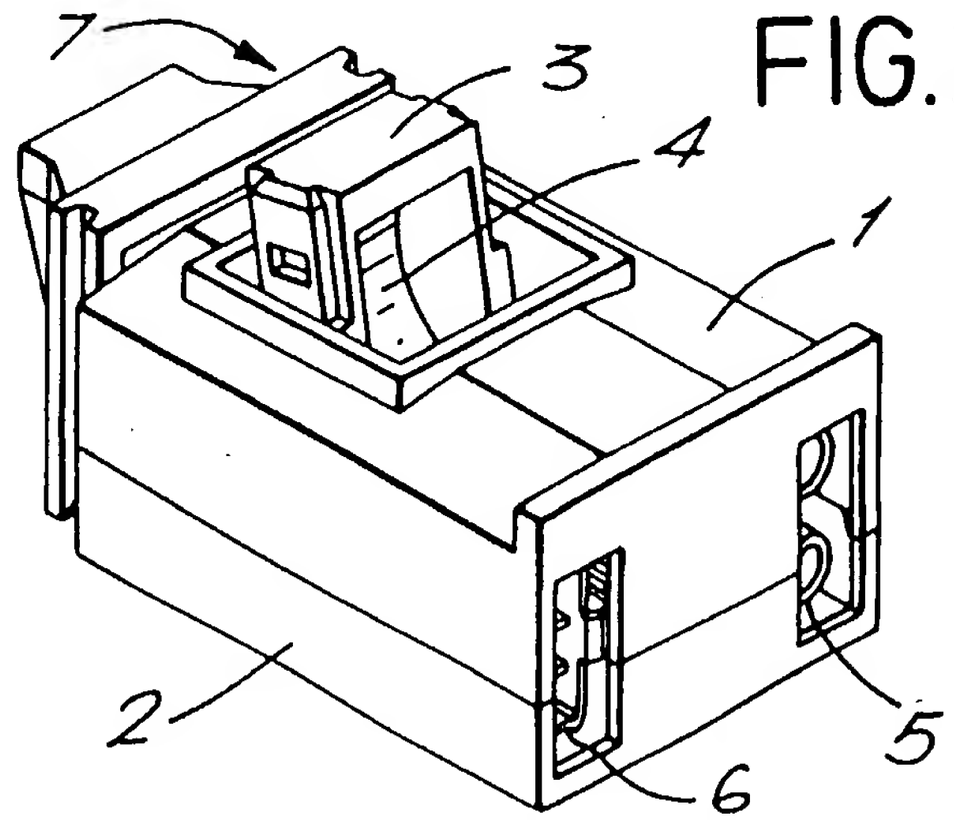


FIG. 2D



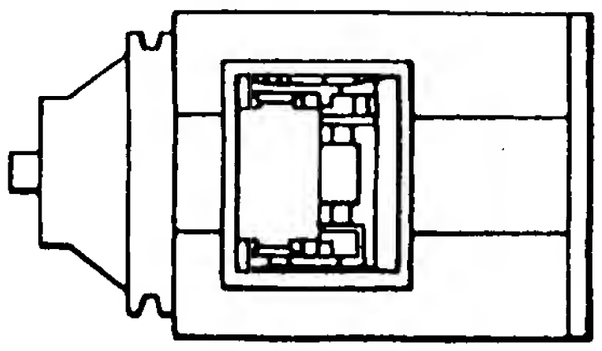


FIG. 2E.

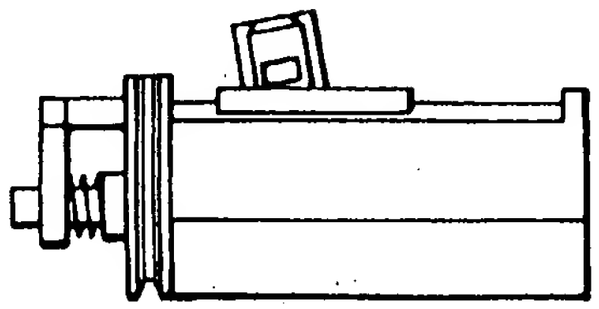


FIG. 2F.

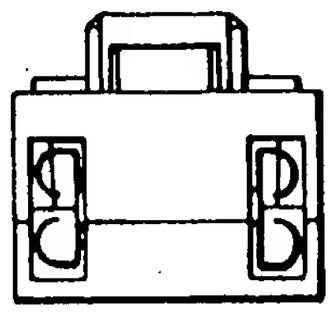


FIG. 2G.

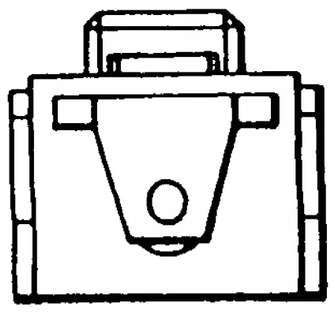


FIG. 2H.

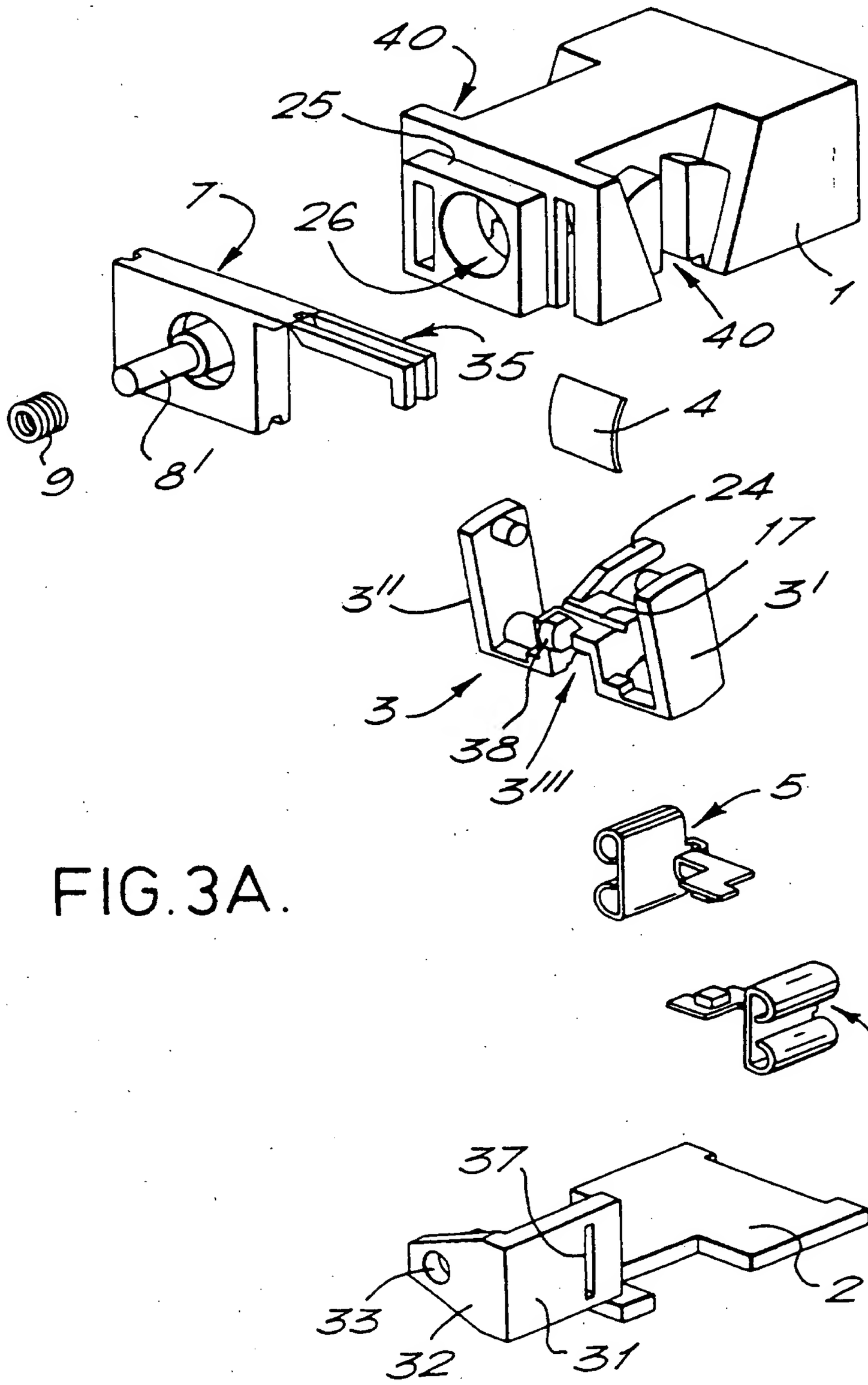


FIG.3A.

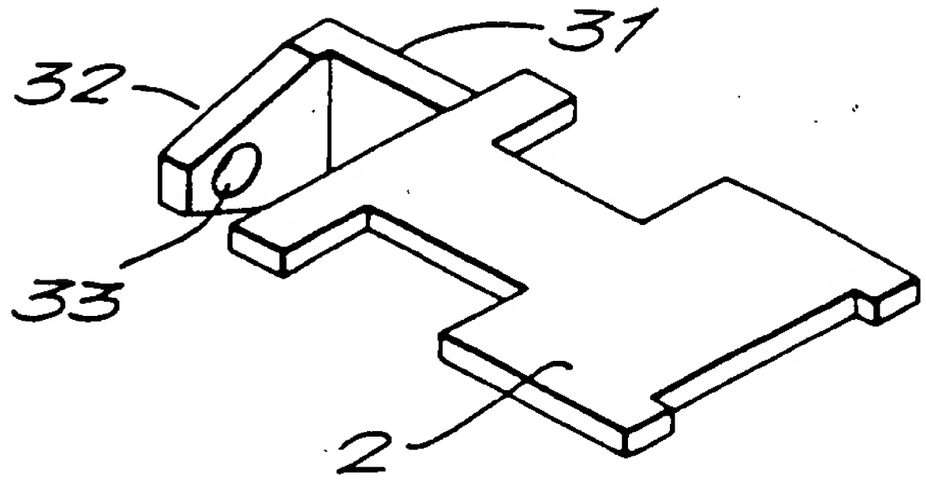


FIG. 3B.

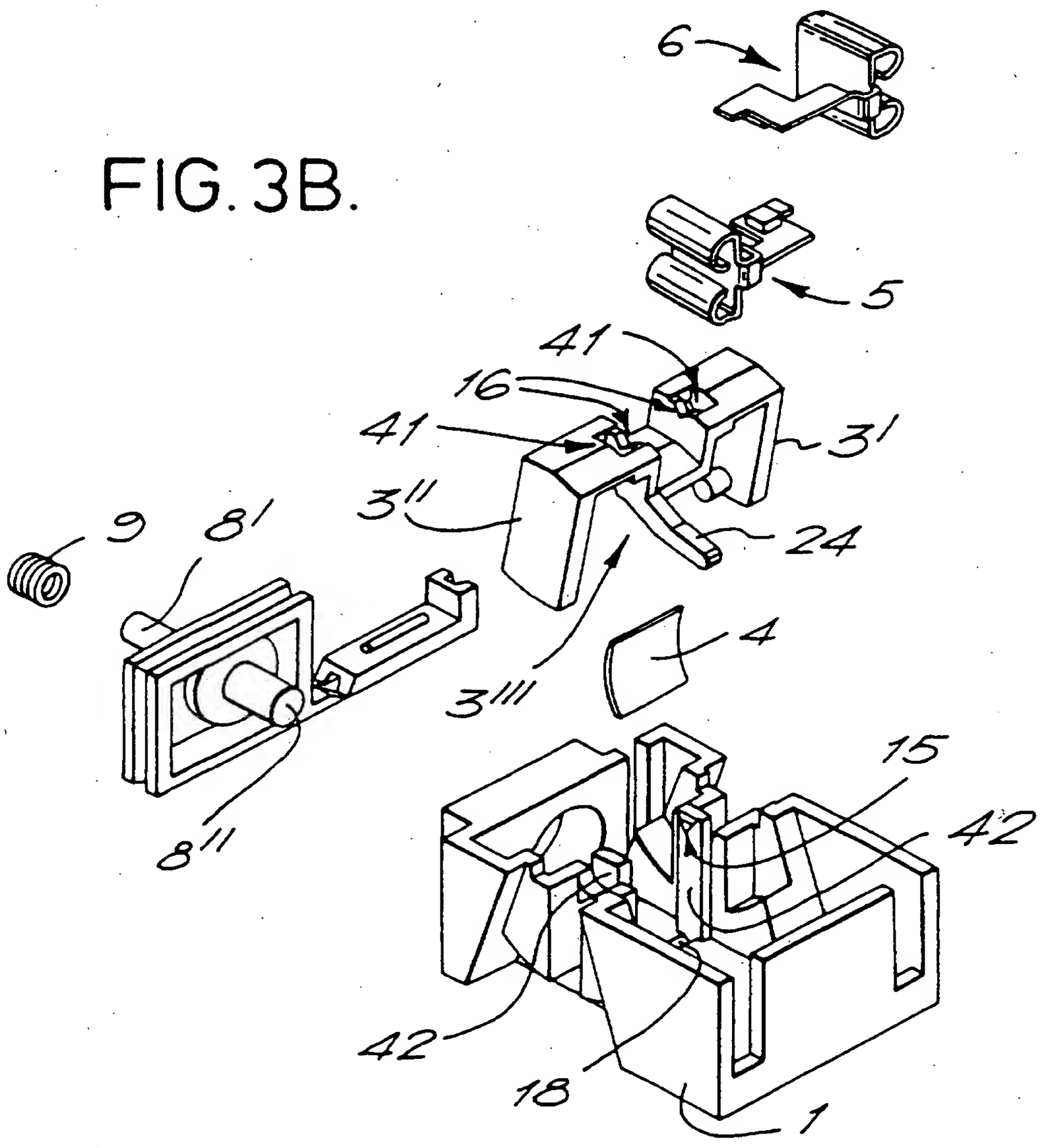
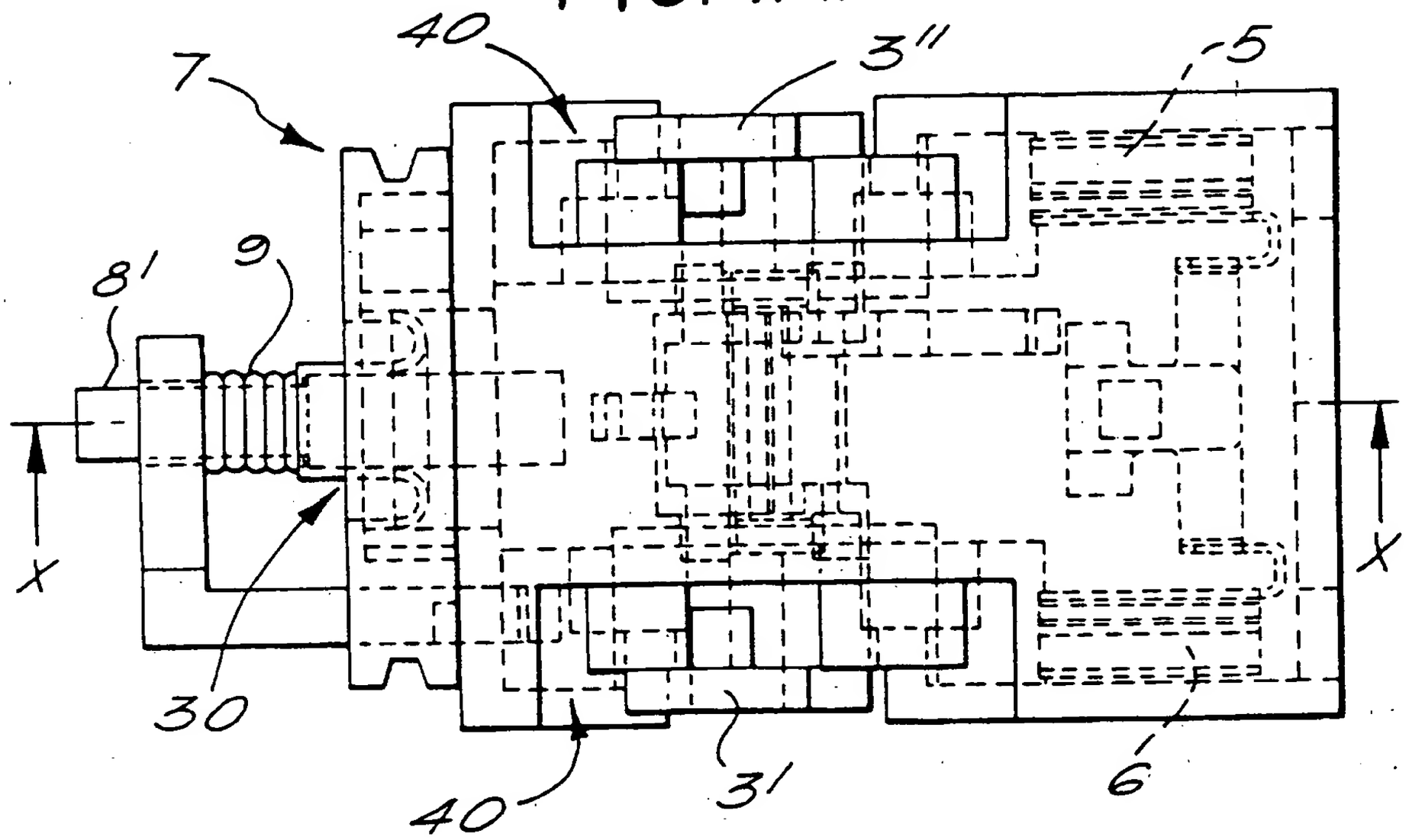


FIG. 4A.



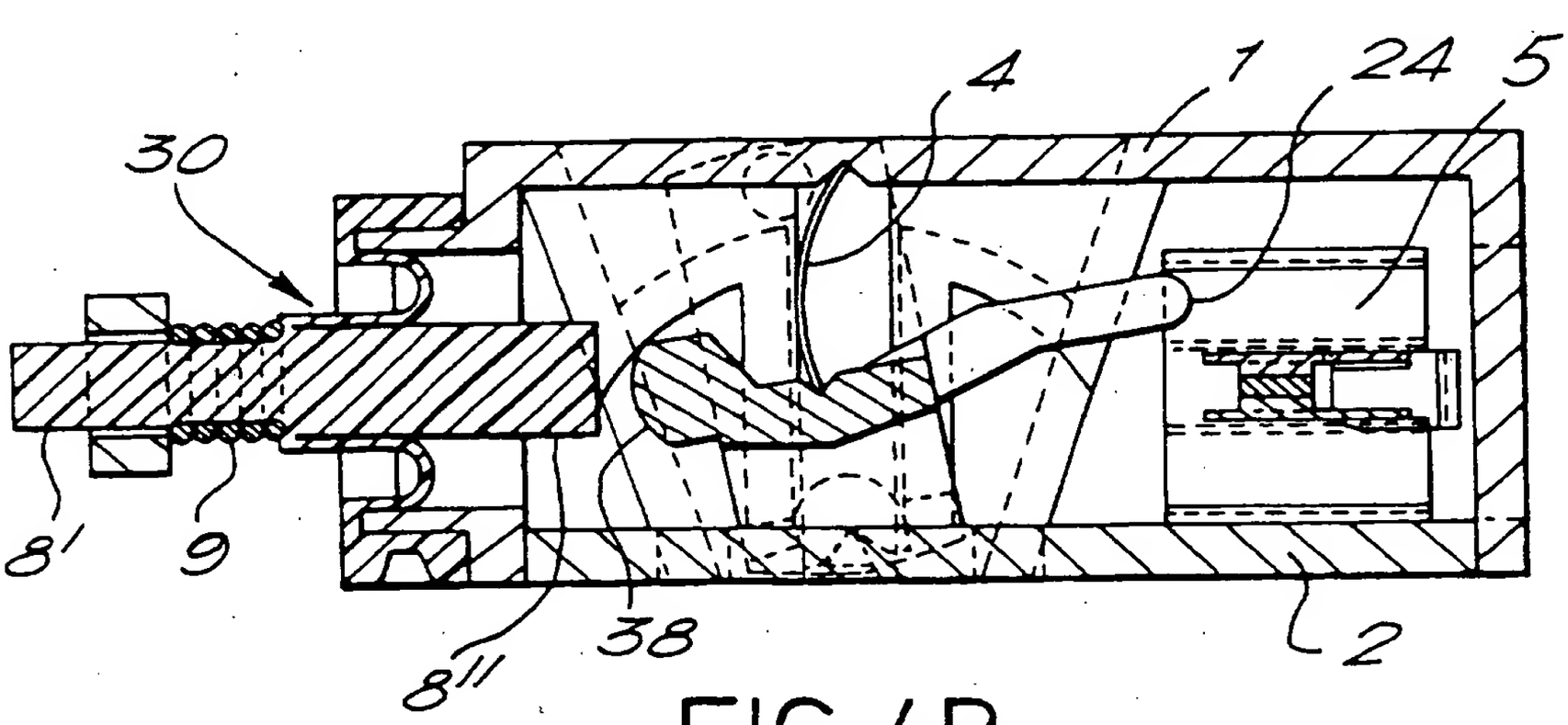


FIG. 4B.

FIG.4C.

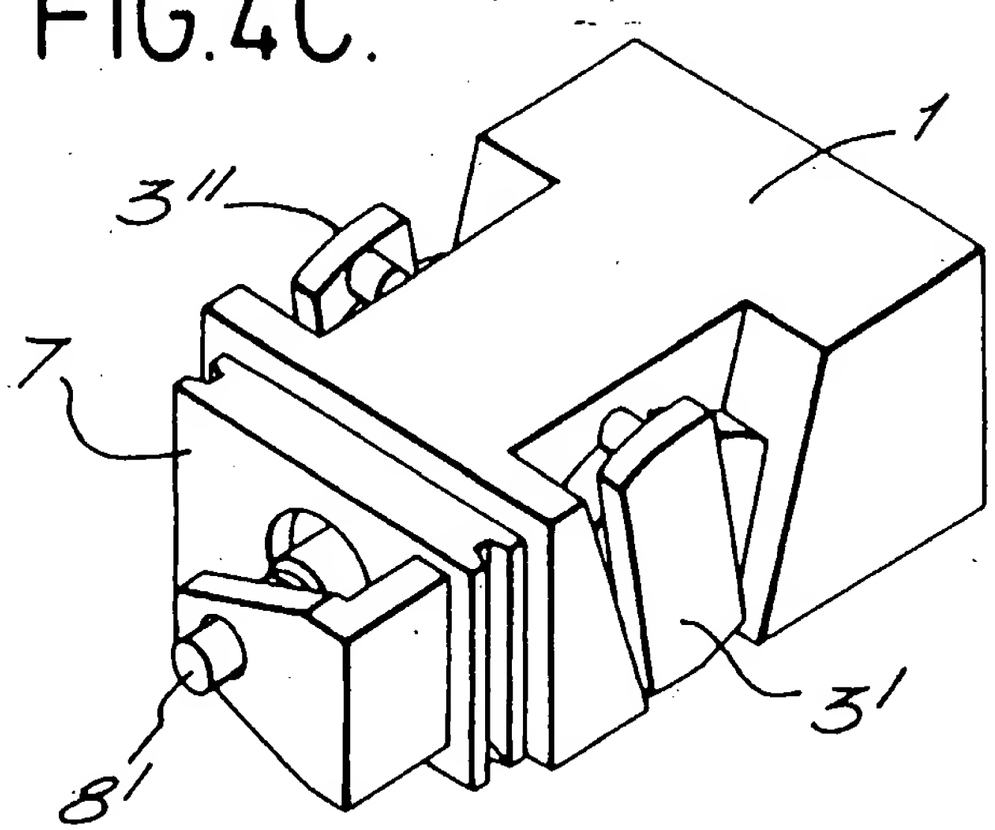
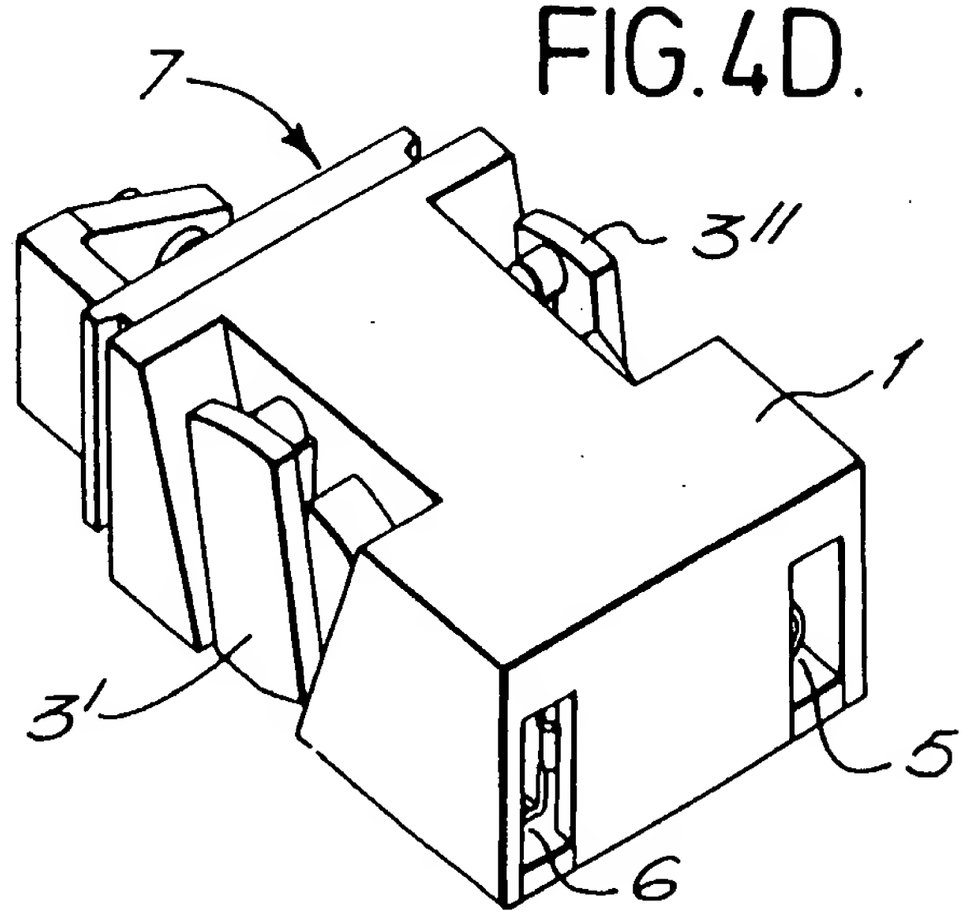


FIG.4D.



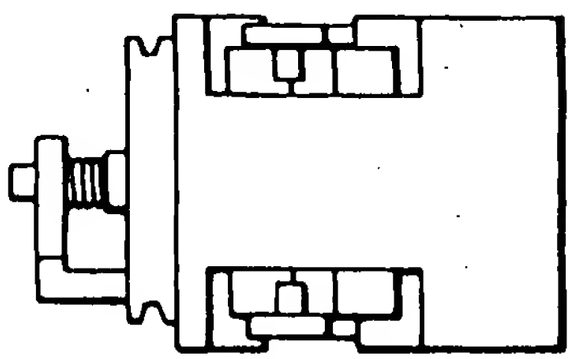


FIG.4E.

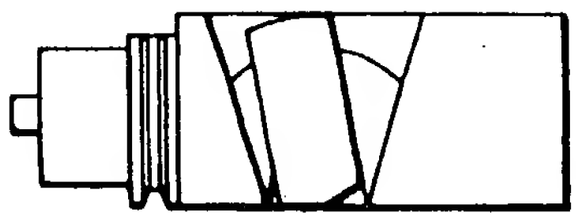


FIG.4F.

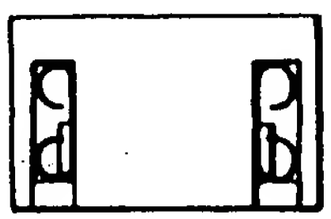


FIG.4G.

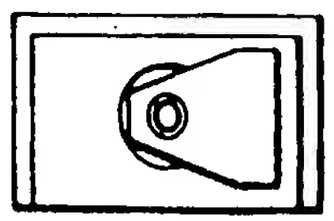


FIG.4H.

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THERMAL CONTROL FOR LIQUID HEATING VESSELS

FIELD OF THE INVENTION:

This invention concerns improvements in or relating to thermal controls for liquid heating vessels and more particularly, though not exclusively, concerns controls for water boiling vessels such as electrically heated jugs and kettles for example in which the generation of steam when water boils in the vessel causes the control to operate so as, for example, to switch-off or reduce the supply of electrical power to the vessel and/or provide some other control indication.

Background of the Invention:

Steam controls for water boiling vessels are well known per se and are likewise well known in combination with so-called element protector controls which are adapted to switch-off the supply of electrical power to the heating element of a liquid heating vessel in the event of a sensed element overtemperature condition caused for example by the vessel being switched on with insufficient or no water in the vessel or by the vessel, in the absence of a steam control or on failure of the steam control, being permitted to boil dry. Known steam controls and

element protector controls commonly make use of bimetal technology, with the thermally-responsive actuator of the control being constituted by a bimetal, commonly a snap-acting bimetal, which is arranged to change condition upon exposure to a predetermined temperature change, for example upon exposure to steam generated when water boils in the respective vessel.

Steam controls are also known in various different forms. Steam controls are known which incorporate a set of electrical switching contacts which have to be closed in order that electrical power can be supplied to the heating element of the vessel, and other steam controls are known which incorporate no switching contacts themselves but merely provide a mechanical switch-actuating movement which is transferred to a separate set of switching contacts, for example in an associated element protector control. It is known furthermore to associate the steam control of a water boiling vessel with a manually-operable ON-OFF control of the vessel, and it has further been proposed to provide an interlock between the base of a so-called cordless electric kettle and the kettle proper to ensure that the ON-OFF control cannot be in its ON condition when the kettle is not standing on its base.

Otter Controls Limited have pioneered the provision of steam controls and element protector controls in water boiling vessels, aided and abetted in their pursuit of excellence in recent times by competition from Strix Limited of the Isle-of-Man. As the patent literature shows, both Otter Controls and Strix, who between them have the lion's share of the World's business in such controls, have employed bimetallic actuators to the exclusion of all other thermal actuators in their steam controls and element protector controls and the reason for this is that bimetallic actuators have consistently provided the best solution to the problems which arise in the design of such controls, namely the provision of reliable and repeated operation within predetermined temperature limits and over tens and perhaps hundreds of thousands of operations, and all at acceptable cost. Bimetal technology is, however, difficult to control and constant and continuous efforts have to be made to control the bimetallic material itself, the way that it is processed, and its interaction with other components of the respective control, particularly moulded plastics parts. The end user of an Otter™ steam control or element protector control may hardly even be aware that their electrically-heated water boiling jug or kettle incorporates steam

and element protector controls, such is their reliability nowadays that they are taken for granted, but in point of fact each Otter™ control is a masterpiece of design engineering evolved over many years of experience of the basically difficult raw materials of the control, namely the bimetal and its co-operating plastics parts.

Summary of the Invention:

The present invention represents, in one of its aspects, a departure from Otter Controls' bimetal technology in favour of shape memory metal technology. Shape memory effect (SME) thermal actuators in the form of shape memory metal helical springs were at one time employed in steam controls for electric kettles, though not by Otter Controls, but proved to be unreliable and uncompetitive with bimetallic controls. As will be explained in detail hereinafter, the present invention, in one of its aspects, resides in the realization that Titanium-Nickel SME alloys, and more particularly Titanium-Nickel-Copper SME alloys, are available which enable a very small helical spring actuator to be designed which exhibits sufficient stroke (movement) with the development of sufficient force, is repeatably reliable in excess of 100,000 operations, and is price competitive on account of its relatively low material content. For example, a

suitable helical spring SME actuator can be designed which has an inner diameter of 1.5mm and three coils which will give a 1 Newton force output at a stroke of 4mm. Because the actuator is a spring, it will generate proportionately higher forces at shorter strokes. The cost of such an actuator is competitive with the cost of a set, snap action bimetallic actuator which typically may provide a similar force output but with a smaller usable stroke.

The use of such an SME actuator, because of its superior force output and stroke, will allow a fully sealed steam control design to be realised with complete waterproofing between the vessel interior and electrical switch contacts provided in the control. This may be achieved, for example, by means of a silicone rubber or other synthetic plastics material diaphragm having additional moulded features forming an O-ring type seal around the periphery of the steam control at its region of interaction with the associated vessel. The force required to move such a diaphragm would prevent the consistently reliable operation of a bimetallic actuator.

The SME actuator, preferably in the form of a helical spring as aforesaid but possibly of alternative form, would be mounted forwards of the diaphragm, that is to say on the steam side of the

diaphragm where it will be exposed to steam generated in the vessel when water boils. Rearward of the diaphragm, a push-rod and/or an overcentre ON-OFF control arrangement might interact with the diaphragm to determine the status of electrical switch contacts as aforesaid provided in the control or to provide mechanical movement to be transmitted by appropriate means to a separate set of switching contacts.

In its simplest form, the silicone rubber (or other material) diaphragm could be moulded integrally with the push-rod which would be sufficiently thick to be effectively rigid. The push-rod could also extend both forwardly of the diaphragm, so as to provide a mounting for the SME actuator, and rearwardly of the diaphragm, for operating the switch contacts, Alternatively, the push-rod could be separately formed and the diaphragm could be moulded around it by insert moulding, or the push-rod could be entirely separate from the diaphragm or could be a separate part but affixed to the diaphragm.

Where an ON-OFF control is provided, it might preferably be in the form of an overcentre spring mechanism which could be arranged to operate a pair of switching contacts. The overcentre mechanism might comprise a trip lever moulding incorporating a pivot or fulcrum feature and a means of mounting a customer

knob, and a spring, for example a C-spring. The switching contacts may be operated by a projection from the trip lever, or by means of a separate push-rod co-operating with the trip lever. The control should desirably be resistant to casual spillage of water over the trip lever, and the provision of a separate push-rod might facilitate this.

The trip lever and/or the customer knob may incorporate water shedding details and, in one embodiment which will hereinafter be described, the trip lever is furthermore mounted within a tubular housing or chimney separated from a contact-carrying portion of the control. A feature extends from the lowest part of the trip lever and rises over an internal barrier for accessing the switching contacts, thereby ensuring that any water falling over the trip lever will pass through holes in the bottom of the tubular housing and cannot access the switching contacts. In an alternative embodiment, which will also be described in detail hereinafter, the steam control comprises an enclosed switch body, and a trip lever is external to the switch body and has features which extend from its lowest parts and enter the switch body proper via holes in its underside to access both a push-rod associated with the diaphragm seal and the switching contacts. This alternative

arrangement makes it very difficult for any water accidentally to access electrical parts of the control and would allow a wider range of mounting attitudes before the water shedding would be compromised.

The above and further features of the present invention are set forth in the appended claims and, together with advantages thereof, will become apparent to those possessed of the relevant skills from consideration of the following detailed description of exemplary embodiments which is given with reference to the accompanying drawings.

Brief Description of the Drawings:

Figures 1A and 1B show in exploded perspective view from opposite viewpoints the component parts of a first embodiment of the present invention;

Figures 2A and 2B show top plan and cross-sectional views of the first embodiment to an enlarged scale, the cross-sectional view of Figure 2B being taken on the line A...A in Figure 2A, Figures 2C and 2D show front end and rear end perspective views of the first embodiment, and Figures 2E and 2H show top plan and side and end elevation views of the first embodiment;

Figures 3A and 3B show exploded perspective views from opposite viewpoints of a second embodiment of the present invention; and

Figures 4A to 4H are views of the second embodiment similar to the views of the first embodiment shown in Figures 2A to 2H.

Detailed Description of the Embodiments:

Referring first to Figures 1A and 1B, the steam control shown therein is shown in its normal, in use attitude in Figure 1A and is shown upside down in Figure 1B. The control has moulded plastics body parts 1 and 2 which fit together as is clearly shown in the drawings, a moulded plastics trip lever 3, a C-spring 4, spring metal terminal parts 5 and 6 each of which is formed to define a receptacle for a spade terminal and, extending therefrom, a limb carrying a silver contact, a silicone rubber diaphragm 7 having an integrally-moulded push-rod 8 and an SME actuator 9 in the form of a helical spring.

As shown most clearly in the lowermost view of Figure 1B and in Figure 2B, the body part 1 has internal walls 10, 11, 12 and 13 which define a tubular passage or chimney 14. Edges at the ends of the walls 10 and 12 are V-notched at 15 to provide pivot points for fulcrums 16 that are provided extending outwardly at the base of the trip lever 3. The trip lever 3 is inserted into the chimney 14 so that its top end protrudes from the upper side of the body part 1 and the fulcrums 16 engage in the pivot

points 15. The C-spring 4 is fitted between a V-groove 17 provided in the upper end of the trip lever 3 and a pair of V-grooves 18, 19 provided in the ends of upstands 20, 21 provided internally of the other body part 2, when the two body parts 1 and 2 are fitted together. The top end of the trip lever 3 is thus able to be moved between stable forward and rearward positions, with a snap action, between an intermediate unstable condition.

An internal barrier 22 is provided in the body part 2 of the control, as may best be seen from the lower view in Figure 1A and from Figure 2B. This barrier 22 defines behind it a region 23 within the control whereat the terminal parts 5 and 6 are received with their receptacles accessible via openings provided in the rear wall of each body part 1 and 2 and their spring metal limbs extending generally towards each other so that their silver contacts can co-operate in switching operations. Note that the terminal parts 5 and 6 are identical, thus avoiding the need to produce right-handed and left-handed parts. With the terminal parts 5 and 6 assembled into the region 23 of the control, they are accessible by a finger 24 which is provided on the trip lever 3, the finger 24 extending from the bottom of the trip lever, under the respective bottom edge of

the chimney 14 and up and over the barrier 22. With the trip lever 3 pivoted forwardly (as shown in Figure 2B), the end of the finger 24 is clear of the spring contact parts of the terminals 5 and 6 , but as the trip lever is pivoted into its rearward position the tip of the finger 24 will engage and depress the lower one of the two spring contact parts (namely the spring contact part of the terminal part 6) thereby causing the switch contacts to open.

The upper end of the trip lever 3, where it projects through the upperside of control body part 1, enables the attachment of an ON-OFF operating knob whereby the pivotal movement of the trip lever can be effected manually. The SME element 9, operating via the diaphragm 7 and push-rod 8, provides for automatic movement of the trip lever 3 from its forward (ON) position to its rearward (OFF) position as will now be explained. At the forward end of the body part 2 there is provided an integrally moulded rectangular formation 25 having a circular through-opening 26. A complementary cut-out 27 is formed in the front end of the body part 1 so that the two body parts can be fitted closely together. On the rear side of the silicone rubber diaphragm element 7 there is provided a recess 28 which is complementary to the formation 25, so that the formation 25 can be fitted snugly and

sealingly into the recess 28, and a hollow, thin walled, circularly-cylindrical boss 29 is located centrally of the recess 28 and is dimensioned to fit snugly into the circular through-opening 26. The push-rod 8 is moulded integrally with, and formed of the same material as, the silicone rubber diaphragm element 7 and has a part 8' which extends forwardly of the diaphragm proper and a part 8'' which extends rearwardly of the diaphragm proper, the diaphragm proper being constituted by the boss 29 and by an integrally-formed thin walled membrane 30 which connects the centre of push-rod 8 to the rearwardmost end of hollow boss 29. This arrangement, as will readily be appreciated, enables push-rod 8 to move without comprising the diaphragm sealing. It is to be appreciated that in Figures 1A and 1B the diaphragm proper 29, 30 and the push-rod 8 are shown in their most rearward condition; the operating condition of these parts is shown in Figure 2B.

Body part 1 of the control has a forwardly-extending portion 31 which has a downwardly-extending part 32 having a circular opening 33 therein for supporting the forward end of push-rod 8 as is most clearly shown in Figure 2B. The silicone rubber element 7 has a rectangular forward part 34 adapted to be sealingly received in a complementary opening in a

vessel wall, and a portion 35 of the part 34 is hingedly attached for sealingly engaging the portion 31 of body part 1 which extends through the part 34, it being noted that a rib 36 is provided on the underside of hinged portion 35 for sealing engagement with a groove 37 formed in the part 34. By virtue of this arrangement a water-tight diaphragm seal is effected between the front end of the control, whereat the SME element 9 is mounted on portion 8′ of push-rod 8, and the remainder of the control on the rearward side of the silicone rubber element 7. The rearward end of push-rod 8 co-operates with a portion 38 of the trip lever 3 for setting the trip lever into its rearward (OFF) condition when the SME actuator elongates in response to being heated by steam and, by reaction against portion 32 of the control body, drives the push-rod 8 rearwards.

The operation of the first embodiment described in the foregoing will be clear without need for further description. The SME element 9 is subjected to impingement by steam from water boiling in an associated vessel and elongates in consequence, thereby driving push-rod 8 rearwardly so as to cause trip lever 3 to move to its rearwardly pivoted position where the finger 24 opens the switch contacts and, by virtue of the bistable nature of the trip

lever movement, holds them open until the trip lever is manually reset. The interior of the control is well sealed from steam impinging upon the SME element 9, and likewise the control is well protected against accidental spillage of water onto the trip lever, for example when the vessel is being filled.

Referring now to Figures 3A and 3B, and to Figures 4A-H, a second embodiment of the invention will now be described. For the sake of brevity, the same reference numerals are used for similar or like parts as were used in the description of the first embodiment and the description which follows will concentrate upon the differences between the two embodiments, rather than their similarities.

The principal difference between the second embodiment and the aforedescribed first embodiment resides in the form and arrangement of the trip lever 3. Whereas in the first embodiment the trip lever is mounted within a chimney formed in the control body parts, in the second embodiment the upper body part of the control is enclosed insofar as spillage of water from above is concerned, and the trip lever 3 is a bifurcated element which straddles the control from beneath and has parts which reach up into the control for co-operation with the rearward end of the push-rod and with the switching contacts. Referring to Figures

3A and 3B in particular, it will be seen that the trip lever 3 has first and second side portions 3′ and 3′′ respectively which are bridged at their lower ends by a portion 3′′′ which carries the finger 24 for operating the switch contacts and also carries an abutment 38 for co-operation with push-rod 8. The control body part 1 has truncated V-shaped recesses 40 in its flanks and these serve to locate the side portions 3′ and 3′′ of the trip lever and provide for pivotal movement of the same. As shown most clearly in Figure 3B, the bridge portion 3′′′ of the trip lever has a pair of apertures 41 formed therein and the fulcrums or pivot points 16 which provide for pivotal mounting of the trip lever are provided adjacent these apertures 41. The body part 1 of the control has a pair of upstands 42 which carry co-operating fulcrums or pivot points 15, the arrangement being such that the formations 15 on the upstands 42 engage with the complementary formations 16 on the trip lever 3 when the trip lever is assembled to the body part 1 by springing the upstands 42 through the apertures 41. With the trip lever 3 thus assembled with the body part 1, the C-spring 4 locates between V-groove 17 formed in the bridge portion 3′′′ of the trip lever and V-groove 18 formed in the underside of the upper surface of body part 1.

Apart from the differences abovementioned, the second embodiment differs from the first only in constructional details which are readily apparent from the accompanying drawings and require no further elaboration. The second embodiment operates in the same manner as the first, but is to be preferred in that it provides greater protection of the electrical switching from accidental spillages and, correspondingly, enables a wider range of mounting attitudes before its water shedding advantages would be compromised.

Having thus described the present invention by reference to particular embodiments, it is to be emphasized that the described embodiments are exemplary only and that modifications and variations are possible without departure from the spirit and scope of the invention. Thus, whereas the SME element in the described embodiment is preferably formed of a Titanium-Nickel-Copper alloy as aforesaid, such an alloy having desirable characteristics for a steam sensing application, it is within the wider ambit of the present invention that it be formed of an alternative material, particularly though not exclusively a Titanium-Nickel alloy, exhibiting appropriate characteristics. Furthermore, while the invention has been particularly described with

reference to steam controls for water boiling vessels, the invention has wider application.

CLAIMS:

1. A thermally-responsive device comprising a shape metal effect (SME) thermally-responsive actuator, a diaphragm seal and means responsive to the condition of said SME actuator and separated therefrom by said diaphragm seal.

2. A thermally-responsive device as claimed in claim 1 wherein said SME actuator comprises a helical coil.

3. A thermally-responsive device as claimed in claim 1 or 2 wherein said SME actuator comprises a Titanium-Nickel or Titanium-Nickel-Copper alloy.

4. A thermally responsive device as claimed in any preceding claim wherein said SME actuator is arranged to determine the condition of said responsive means through the intermediacy of a push-rod.

5. A thermally responsive device as claimed in claim 4 wherein said diaphragm seal is formed of a synthetic plastics material and said push-rod is formed integrally therewith as an integral part thereof or by a process of insert moulding.

6. A thermally-responsive device as claimed in any preceding claim wherein said synthetic plastics material is a silicone rubber material.

7. A thermally-responsive device as claimed in any preceding claim wherein said responsive means includes a set of electrical contacts.

8. A thermally-responsive device as claimed in any preceding claim wherein said responsive means includes an overcentre spring arrangement.

9. A thermally-responsive device as claimed in claims 7 and 8 wherein the condition of said overcentre spring arrangement determines the status of said set of switching contacts.

10. A thermally-responsive device as claimed in claim 8 or 9 wherein said overcentre spring arrangement includes a manually-operable trip lever.

11. A thermally-responsive device as claimed in claim 10 wherein said manually-operable trip lever is movably mounted in a passageway formed in a body part of the device, said passageway providing for fluid flow past the trip lever.

12. A thermally-responsive device as claimed in claim 10 wherein said manually-operated trip lever is arranged to access the interior of a body part of the device substantially through the underside thereof.

13. A thermally-responsive device as claimed in any preceding claim configured as a steam sensor for a water boiling appliance.

14. A thermally-responsive device as claimed in claim 13 and substantially as herein described with reference to Figures 1 and 2 or Figures 3 and 4 of the accompanying drawings.

15. A water boiling appliance incorporating a steam sensor as claimed in claim 13 or 14.

16. A thermally-responsive sensor comprising a sensor body part incorporating one or more components the condition whereof is to be determined in dependence upon the sensed temperature, a diaphragm seal provided in a wall portion of the sensor body part, and a thermally-responsive element outside of said sensor body and coupled via said diaphragm seal with said one or more components.

17. A thermally-responsive sensor as claimed in claim 16 wherein the thermally-responsive element comprises an SME element.

18. A thermally-responsive sensor as claimed in claim 16 or 17 wherein said thermally-responsive element is arranged to operate a set of switching contacts and/or a trip lever within the switch body.

19. A thermally-responsive sensor as claimed in claim 16 or 17 or 18 wherein the diaphragm seal incorporates a push-rod for determining the condition of said one or more components within the sensor body, said diaphragm seal being formed of moulded synthetic plastics material and the push rod either being an integral part of the diaphragm or being insert moulded therewith.

20. A thermally-responsive sensor as claimed in any of claims 16 to 19 wherein said diaphragm is formed of silicone rubber or of a synthetic plastics material having similar physical characteristics.

21. A control for an electrically heated water boiling appliance, said control comprising a body portion housing electrical switch contacts, and an

operating member accessible for manual operation at an upper part of said body portion and arranged to access the interior of said body portion for determining the condition of said switch contacts substantially through an under part of said body portion.

23

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A BURROWS

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19 JUNE 1995

Databases (see below)
(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

(ii) ONLINE: WPI

Documents considered relevant following a search in respect of Claims :-
1-15

Categories of documents

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X:Y	GB 2214355 A	(ABC-ELEKTROGERATE) whole document	X: 1, 2, 7-13 Y: 3, 4
X:Y	GB 2174548 A	(NITTAN) whole document	X: 1, 2, 3, 4, 7 Y: 6
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